distinct faunistic factors seem to have played a part. The North-American element is represented by two, no doubt artificially introduced, species of white ants, and certain large dragon-flies, which having flown over at some time continue to breed. The Australian element is very small, and probably consists solely of the single ant-lion, which may be regarded as Polynesian. The strictly endemic element is the largest, and is represented by (*inter alia*) the Agrionidæ and the peculiar forms of Chrysopidæ, two groups of very different habits—the former necessitating a constant supply of fresh water with aquatic animal life for food, the latter a supply of small soft-bodied plant-frequenting insects on which their larvæ feed.

Such, then, is my opinion on the materials for the order of insects of which I have made a special study; but any broad generalization on the Insect-fauna must be left until the reports of other specialists on the results of Mr. Blackburn's investigations can be collated and correlated.

XXXIV.—*On the Answerable Divisions of the Brain in Vertebrates and Invertebrates.* By Prof. Owen, C.B., F.R.S., &c.

The principles or generalizations of homology and analogy force themselves on the attention of naturalists in many relations, and suggest questions on divers subjects. Take the heart of a Cephalopod, for example. Is it the homologue or the analogue of that of a fish? Is its relation thereto only that of identity of function, sometimes expressed by the term "homodynamous," which is synonymous with "analogous" in questions of this nature?

No naturalist, it may be presumed, doubts the homology as well as analogy or homodynamy of the heart of the cuttle-fish with the heart of the snail. If the latter were propounded as the subject of the inquiry, a biologist of eminence might pronounce that it was merely homodynamous with the heart of a fish, conceiving relations of position to be essential in determining the question of homology. Accepting the current views of such topical relations he might, probably would, reply, "The heart of the snail is on the back or 'dorsal' aspect of the body, while that of the fish is on the opposite or 'ventral' aspect."

Generalizing such particular questions and accepting the current replies, he would be justified in affirming that there was no homology between the vascular centres or systems of Vertebrates and Invertebrates.

The same conclusion, on the above assumption of their respective backs and bellies, affects another and, in this relation, more important organic system. Homology would be repudiated as between the myelencephalon of Vertebrates and the centres of the nervous system in Articulates. In the former the "brain," and, as in *Amphioxus*, a more constant part, viz. the "spinal marrow," are held to be on the "dorsal" aspect of the body; in Articulates the ganglionic chord, functioning as "spinal marrow," is held to be on the "ventral" aspect of the body. They may be, accordingly, "analogous" or "homodynamous," but are not answerable parts in the "homologous" sense.

An exception is indeed made by some zootomists in favour of one portion of the neural axis:—"The central nervous system of the Vertebrata is to be regarded as representing the superior or cerebral ganglia of Invertebrata" *,—that is, as being homologous with such ganglia and with their coalesced and developed condition in the Cephalopod; although, in fact, the part described as "brain" in such Invertebrate represents no more than the part of the brain in Vertebrates which is in connexion with the senses of sight and smell.

The ground, in short, on which such conclusions are based is simply that of the relative position to a part or aspect of the body as this may be carried by the animal during locomotion.

But before testing the value of such support of the conclusion, as it affects the question of homology, I may refer to the degree in which it checks or paralyzes another and higher biological line of thought. Gegenbaur, for example, finds it "quite impossible to derive the spinal chord from it" †, that is, to derive phylogenetically the continuous or more or less uniform myelon of Vertebrates from the ganglionic myelon of Arthropods and Annulates. I by no means think that a study of their developmental relations is to be abandoned in despair, the answerable aspects being rightly determined. But, before moving further on this line, I may remark that enlargements at the points where nerves communicate with

* Gegenbaur, 'Elements of Comparative Anatomy,' Ray Lankester's edition, 8vo, 1878, p. 501. Prof. Packard, more consistently, repudiates even this degree of homology (see his 'Second Report of the U.S. Entomological Commission,' 1880, p. 224).

† *Op. cit. ib.*

or pass from the Vertebrate myelon are many in some fishes (e. g. *Trigla*), and they are present, though in smaller number, in the short myelon of *Orthagoriscus* *; and, further, that the researches of the microscopist and the experiments of the physiologist have led to the conclusion that the seemingly continuous and uninterrupted tracts of the spinal chord of Vertebrates are due to a coalescence through superadded or interposed neurine of as many ganglionic centres receptive of neural impressions, sensory or motory, which essentially are as distinct, or in as special topical relations to the nerves proceeding from or returning to such centres, as are the physically seemingly separate centres in the so-called "ventral ganglionic chords" of Invertebrates †.

To what indeed are the grounds of such above-cited judgments on the important homological questions at issue reduced when subjected to anatomical analysis?

One of the several ganglionic enlargements of the knotted chord and centre of the nervous system in Invertebrates is propounded as the homologue of the brain in Vertebrates; and I accept such homology, but only in the restricted sense or degree above noted. For I hold that the neural centres in relation to the sensations and motions of the tongue, jaws, and other parts of the mouth in Invertebrates, which centres are in direct communication through continuous "crura" or chords with the so-called "brain," are physiologically answerable to the parts of the brain with like nerves and functions in Vertebrates.

That there are parts of the Vertebrate myelencephalon which correspond with, are certainly analogous to, and, I believe, homologous with, such parts in Invertebrates, I have elsewhere endeavoured to demonstrate ‡. The sole ground for rejecting such homology, or for its restriction to a part only of the brain of Invertebrates, is a different relation of the gullet to the prot- and metencephalous masses in Vertebrates and Invertebrates. The space dividing the fore brain ("protencephalon" of Vertebrates, "supercesophageal ganglion" of Invertebrates) from the hind brain ("epencephalon" of Vertebrates, "subœsophageal ganglion" of Invertebrates) is so reduced in Cephalopods, especially the Dibranchiates, that the recognition of their homology with the corresponding divisions of the brain in Vertebrates becomes obvious.

The intervening space is scarcely, if at all, less in the

* 'Anatomy of Vertebrates,' vol. i. 1866, p. 271.
† Newport, Phil. Trans. 1843, p. 243.
‡ 'Aspects of the Body in Vertebrates and Invertebrates,' 8vo, 1833.

brains of the lower Vertebrates. It needs only to refer to the comparative anatomy of the brains of fishes; and here I would refer to a late contribution thereto by the accomplished "Docent der Anatomie zu Berlin," the "Oberstabsarzt Dr. Rabi-Ruckard," entitled "Das Grosshirn der Knochenfische und seine Anhangsgebilde." A reference to the figures 1 and 2 of Taf. xii. of this memoir in the 'Archiv für Anatomie und Physiologie,' 1883, of a trout's brain (*Salmo fario*) suffices to show the homologous space under the name of "ventriculus tertius." It is one of the demonstrations of the foregoing homology. The amount of neurine in the lateral walls of this interspace due to the continuation of cerebral tracts homologous with those uniting the prot- and epencephalic divisions of the Cephalopodal brain, commonly termed "supra-" and "infra-œsophageal" ganglions, is somewhat greater in the fish, and the alimentary tract which in the Cephalopod traverses that interval, is represented in the Vertebrate by the modified remnant of the primitive gullet. This remnant extends upward (dorsad) beyond the fish's brain, penetrates the cartilaginous basis of the frontal bone, and is there arrested; in the opposite or "ventral" direction the "transcerebral tract" extends into the cartilaginous basis or floor of the cranium, which shuts off its original communication with the pharynx; the so-obstructed or closed parts of the transcerebral tract are converted into the parts called respectively the "pineal" and "pituitary glands," with the intervening "ventricle" and its "infundibular" prolongation.

Influenced by the foregoing facts, and reasonings thereupon, I deem the grounds for restricting the homologies of the nerve-centres of Vertebrates and Invertebrates to one portion only of the brain of the latter, known as the "supra-œsophageal ganglion," to be inadequate; and a sense of this inadequacy led me to institute the series of embryological and other researches on the conditions of the course of the gullet through the brain-centres of Invertebrates which were submitted to the Biological Section of the British Association at the Meeting held at York in 1881*. This communication was followed by the "Researches on the Homologies of the Neural Centres, their Parts and connected Nerves," submitted to the Linnean Society of London in 1882†.

The conclusions to which I was led enabled me, or seemed to me, to show that the position in which the body of an animal is carried in relation to the earth's surface is of less

* "Reports," &c. in 'Transactions of the British Association,' &c. for 1881. 8vo.

† 'Journal of the Linnean Society,' Zoology, vol. xvii. 1882.

value in determining the homology of its aspects than are the relative positions of the nervous and vascular centres to a given surface or aspect of the body. I concluded, therefore, that the "neural surface" of an Arthropod, indicated by the position and course of the main or central part of the nervous system, was homologous with the surface or aspect of the body so indicated in a Vertebrate; also that the condition which seemed to alter that relation in respect of a small part of the neural axis, in the Invertebrate, was inadequate to affect conclusions of homology based on the permanent relations to surfaces of the body shown by the nervous and vascular centres respectively, especially as such condition, affecting a small part of the Invertebrate nervous system, was discernible, though transitory, in the brain of the Vertebrate embryo.

Consequently I proposed to apply the term "neural" to the surface or aspect of the body which in progressive motion is carried upright and directed backward in man, and to apply the term "hæmal" to the surface or aspect of the body which is carried upright and turned forward in man; and I proposed to apply the same terms to signify homologous surfaces indicated by the positions of the nervous and vascular centres, which surfaces are horizontal and are carried respectively upwards and downwards in Vertebrates below mankind, but are carried downwards and upwards respectively in the Invertebrates above the "Radiaires" of Cuvier.

In higher members of this division (the starfish for example) the homologue of the "œsophageal ring" is the centre of the nervous system. As organization progresses the portion of the ring opposite to the part or aspect on which the mouth opens becomes the seat of developments in relation to the necessity of a provision receptive of impressions or influences affecting the more exposed and upturned surface of the body. Next follows the prolongation of the post-oral part of the frame, which may be segmented and cuirassed in some or be left soft and unjointed in others. But the primitive neural ring round the gullet remains in both the Annulate and Molluscous series. Such course of the gullet is finally checked at the higher Vertebrate stage by the development of a branchial chamber which takes in the materials for digestion as well as for respiration.